Collaborative Research Projects in Support of FNMOC Operational Mission

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LONG-TERM GOALS

The long-term goal of this project is to support NPS Meteorology and Oceanography thesis efforts on research problems of the Fleet Numerical Meteorology and Oceanography Command in Monterey.

OBJECTIVES

This project supported the four collaborative theses in the Department of Meteorology of Naval Postgraduate School. They include validation of the FNMOC display of ERS-2 scatterometer winds, development of perfect prog statistical forecasts from NOGAPS, NOGAPS cloud forecast validation and testing the new FNMOC product, METCAST.

APPROACH

The specific projects supported under this proposal were developed by mutual agreement between an NPS thesis student, an NPS-Meteorology faculty member (Thesis Advisor) and an FNMOC employee with whom the NPS personnel will collaborate. Projects are approved by the Chairman of the NPS Meteorology Department and by the FNMOC Technical Director. This report will describe the NPS theses completed or in progress during 1998 under this project.

WORK COMPLETED AND RESULTS

Two collaborative research projects have been completed with support received in FY97 and FY98, one is near completion, and one is in progress.

The two complete theses are: "Comparison of the Naval Operational Global Atmospheric Prediction System Cloud Analyses and Forecasts with the Air Force Real Time Nephanalyses Cloud Model" by Air Force Captain Gary Marsteller (NPS Advisor – Professor R. T. Williams, FNMOC Contact – Dr. Mary Alice Rennick, NRL Contact – Dr. Tim Hogan) and "Comparison of Evaporation

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duct Height Measurement Methods and their Impact on Radar Propagation Estimates" by Navy LCDR John Whalen (NPS Advisor – Professor K. L. Davidson, FNMOC Contact - Chuck Skupniewicz). CAPT Marsteller's thesis compares Air Force RTNEPH and FNMOC NOGAPS analyses for high, middle, and low clouds during January 1998 and October 1997. NOGAPS forecasts at 12, 24, 36, and 48 h are compared with the appropriate RTNEPH analyses. The difference fields averaged over a month show a rapid increase in the first 12 h over the forecast, followed by a slow growth to 48 h. The rapid increase is caused by model adjustment. The RTNEPH and NOGAPS (including forecasts) are separated into nine categories: clear, 0-20, 20-40, 40-60, 60-80, and 80-100. When the clear and 0-20% categories are combined, the RTNEPH and NOGAPS analyses compare well for high and middle clouds. However, the RTNEPH and the NOGAPS analyses are distributed differently for the other categories, and the RTNEPH has many more occurrences for the cloudiest category (80-100%). For low clouds the RTNEPH and the NOGAPS are quite different, since the RTNEPH has difficulty analyzing low clouds at night. The NOGAPS and the RTNEPH (except for low clouds) generally agree on the clear areas. However, it appears that NOGAPS underestimates the number of mostly cloudy cases and the distribution of categories is different.

LCDR Whalen's study was performed to compare shipboard measurements of atmospheric parameters that impact the evaporation duct and its effect on the propagation of electromagnetic energy from the AEGIS AN/SPY-1 radars. Two ships, USS ANZIO and USS CAPE ST GEORGE, participated in the annual NATO exercise, BALTOPS, during the summer of 1997. They were equipped with an automated METOC sensor system, developed by Johns Hopkins University Applied Physics Laboratory, called SEAWASP. SEAWASP provided continuous measurement of parameters determining near surface refractivity and the evaporative duct throughout the cruise. SEAWASP data were compared with manual bridge observations in order to illustrate the difference in propagation conditions assessed by the two methods. Additionally, ERS-1 Scatterometer wind data were used in conjunction with SEAWASP data to determine the feasibility of incorporating satellite wind data from FNMOC in determining evaporative duct heights. The automated SEAWASP data was able to depict, with greater accuracy, the constantly changing duct height conditions whereas the bridge observations, made at hourly intervals, lacked temporal resolution thereby missing much of the variation in duct height. The discrepancies in duct heights between the two measurement systems led to differing propagation ranges resulting in shorter reaction times to counter threats to the ship. In the planning stages of this thesis, scatterometer data from both ERS-2 and NSCAT, processed at FNMOC, were anticipated. Unfortunately, NSCAT data stopped at the beginning of the cruise and significantly reduced the amount of FNMOC scatterometer displays that could be studied in this thesis. Some FNMOC scatterometer winds from ERS-2 were analyzed in the thesis however.

The third thesis is entitled: "An NWP-Perfect Prog Model for Selected Weather Elements." This thesis will be completed in the next several months by LT Brian Bommarito. NPS Advisors are Professor C.-P. Chang and Dr. J.-M. Chen (who was hired by FNMOC) and the FNOMC Collaborator is Dr. Mary Alice Rennick.

The goal of the thesis project is to build a prototype statistical forecast model that uses a NWP output to forecast weather elements such as ceiling height and probability for precipitation at particular locations. This is in response to one of the FNMOC request items to develop a weather element forecast model that uses NOGAPS and NORAPS outputs. Eventually, for operational applications, the NOGAPS and NORAPS/COAMPS will be the NWP model to provide the NWP output, but there is not

long enough homogeneous data from any of these models. So the approach in this project is to develop "Perfect Prog" model. The gridded data from NCEP reanalysis were used to develop a regression model to predict the weather elements at selected locations that are of interest to Navy operations. The development includes control tests to evaluate the skill range based on standard Brier and other skill scores.

One of the most important considerations is the proper selection of the predictor fields. This is mainly to minimize the sensitive round-off errors due to multicollinearities, as most meteorological data are highly intercorrelated. Thus, extensive step-wise regression and similar techniques are usually required in building the model output statistics for perfect prog models. Since the time period for a thesis project is limited, the conventional step-wise regression for model output statistics was too time-consuming.

Instead, this project used a two-step principal component analysis (PCA) on the predictor fields to remove multicollinearity and to maintain reliability through truncation. The first step is to preprocess each predictor field with a PCA. A portion of the resultant principal component (PCs) are selected by considering the individual correlation coefficient between each PC and the predictand. The second step is to normalize the chosen PCs of each predictor field and combine them to form a single data set. The combined set is then subjected to a PCA with the resulting PCs used as the direct predictor elements to construct the regression model.

Since all PCs are not intercorrelated, there is no problem of multicollinearity in the above procedure. There remains a potential problem of reliability for the trailing components that are now normalized. This is a significant problem because the maximization of reliability and the maximization of predictability are inherently conflicting with each other, therefore additional variance truncations and correlation re-evaluations may need to be performed.

The final thesis project is in progress at this time. LT Brian Connon is working with Mr. Dave Huff at FNMOC to create and test a conceptual model for METOC sensor and product display and communications aboard ships without an embarked METOC division, i.e. cruisers, destroyers, frigates, etc. Traditionally, HF facsimile and hard copy message traffic have provided the majority of support to small ships. As Carrier Battlegroups become more dispersed and the battlespace moves closer to the coast, the need for improved METOC support to small ships dramatically increases. LT Connon plans on using METCAST, developed by FNMOC, to improve the timeliness and quality of METOC products available, the ADNS SIPRNET communications link for the transfer of information from shore to deployed small ships, and the shipboard sensor suite, MORIAH to provide accurate and continuous in-situ surface measurements. The ultimate goal of this thesis is to take a combined METCAST/MORIAH system to sea during the winter quarter in order to test the transfer of METOC data and products to a small combatant. This project will be complete June 1999.

IMPACT/APPLICATIONS and TRANSITIONS

From this thesis work, FNMOC received validation of its scatterometer wind product and evaluation of the ability of NOGAPS to forecast low, middle and high cloudiness. In addition, consideration progress was made on a statistical approach to improve the NOGAPS forecasts of precipitation and the testing of a new FNMOC product, METCAST.

REFERENCES

Bommarito, B., (1998) A principle component Approach for FNMOC Probability of Precipitation Forecast. M. S. Thesis, Naval Postgraduate School, (to be completed in September 1998).

Marsteller, G. F. (1998) Comparison of the NOGAPS Cloud Analyses and Forecasts with the Air Force Real-time Nephanalysis Cloud Model. M. S. Thesis, Naval Postgraduate School, June 1998.

Whalen, J. D., (1998), Comparison of Evaporation Duct Height Measurement Methods and their Impact on Radar Propagation Estimates. M. S. Thesis, Naval Postgraduate School, June 1998.

IN-HOUSE/ OUT-HOUSE RATIOS

100% of the work has completed at the Naval Postgraduate School.